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Lecithins: A Food Additive Valuable for Antifungal Crop Protection

M. Jolly, R. Vidal and P. A. Marchand*

Institut Technique de l'Agriculture Biologique (ITAB), 149 rue de BERCY, F-75595 Paris CEDEX 12, France

Corresponding Author

P. A. Marchand
e-mail: patrice.marchand@itab.asso.fr

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Abstract

Lecithins area generic term to designate group of fatty substance in animal and plant tissues. Despite is low solubility in water, lecithin is an excellent emulsifier. It's used as a food additive for smoothing food textures. Lecithins are also described with plant protection capacity as fungicide. In order to confirm the utility of lecithins in crop protection, experimentations were developed by our institute. Fields trials were coordinated in France by the "HE" Casdar program between 2013 and 2016. The antifungal properties of lecithins were tested against mildews in organic and non-organic farms. Typical used concentrations of lecithins in water are from 75 to 200 g hl^{-1} and amounts from 75g to 2 kg ha^{-1} for fungicide uses. Positive results conduct to legalize agricultural application. Lecithins are now approved as basic substance with fungicide properties in EU.

Keywords: Lecithins, fungicide, biopesticide, downy mildew, powdery mildew

1. Introduction

Lecithin is a generic term to designate any group of yellow-brownish fatty substances occurring in animal and plant tissues composed of phosphoric acid, choline, fatty acids, glycerol, glycolipids, triglycerides, and phospholipids. Lecithin has emulsification and lubricant properties, and is a surfactant (FAO, 2007). Lecithins are used for applications in human food, animal feed, pharmaceuticals, paints, and other industrial applications (Szuha, 1989; EU, 2017).

Outside from the food environment, considering its properties, few people tried to use it as plant protection product (Dayan, 2009) and some patent were launched early (Ghyczy et al., 1987) but level of efficacy were lower than conventional fungicide. Today, low concern biorationals are needed to replace chemical for different reasons (environment contaminations, metabolite considerations, resistances, withdrawal…) thus even less efficient crop protection products are gaining interest (Bohinc, 2015).

2. Materials and Methods

2.1. Fields experiment and trial

Between 2013 and 2015 in France, field trials were conducted in the « HE » Casdar program. Lecithin was tested as fungicide against grape downy and powdery mildew (*Plasmoparaviticola, Erysiphenecator*) in vineyard (organic and non-organic farms) (Vidal, 2016).Previous experimental lecithin studies validated natural uses. Many uses of the product are now affordable and effective for plant protection. Clearly, this substance is fully within the scope of the Recital 18 of Regulation (EC) No 1107/2009 concerning food status and utility in crop protection. Regulatory expertise on lecithin as a natural substance allows the development of a new alternative to the use of pesticides for plant protection. Included in this protection is the formation of a physical barrier. Lecithins are indeed non-biocidal; it prevents the spread of fungal diseases without killing the fungi. This information is significant, considering the importance of reducing pesticides toxicity while meeting the expectations of organic producers (Lichtfouse, 2013).

2.2. Ecotoxicological assessments

According to the EU Department of health and human service, lecithinsare authorized for use in food with no limitation other than current good manufacturing practice. Lecithinsare affirmed as safe for food use by the Office of Food Additive Safety and are approved as a food additive under other internationally recognized standards (DHHS, 2012). Lecithinsare also classified (Pino, 2013) as "Generally Recognized As Safe" (GRAS). Lecithinsare practically nontoxic to aquatic organisms. Should lecithin be released into the environment, it is considered readily biodegradable. Lecithins are not expected to be persistent norbioaccumulative (DuPont, 2012). Moreover, lecithinsarealso bee food products (Feo, 1957) and no adverse effect is described in literature (PAN

Pesticides Database, 2017).

2.3. Recipes

Solutions in water were tested and defined during field trials or identified from the literature and checked. Whenever water is mentioned in these tests clearly natural spring or cold rain water is used. Typical used concentrations of lecithin in water are from 75 to 200 g hl^{-1} and amount from 0.075 to 2 kg ha^{-1} for fungicide use (Marchand, 2016).

3. Results and Discussion

3.1. *Plant protection products with non-biocidal mode of action*

Lecithin solution is intended for field use as fungicide on vineyards, fruit trees, vegetable gardening and ornamentals (Misato et al., 1977; Trdan et al., 2008). In the field concentrations of lecithin between 0.01 and 0.1% provide protection between 25 to 30% against *Plasmopara viticola* on grapevines. However, a lower concentration of 0.05% is more effective than in vitro assays at higher concentrations (0.5%) (Aveline et al., 2013).

Statistical difference with control (no treatment or water control) is positive for all concentrations (0.01 to 0.2%) with foliar disks. An additional field efficacy trial demonstrated a reduction of powdery mildew contaminations in vineyards, which supports the existing registration of lecithin in Switzerland and the use at 75–200 g hl^{-1} concentration.The activity of lecithins as antifungal substance is done by direct contact (Castillo, 2012); lecithins inhibit mildew spores germination.

3.2. *Lecithin classified as basic substance*

Lecithin is therefore a natural product of little concern that triggers and amplifies the plantsdefences as elicitor. This product is operational in Europe and is part of the substances called base substance. The basic substances are substances of natural origin (Marchand, 2015; 2016) ultimately come from a food product. Lecithins are a foodstuff (EC, 2002) thus intrinsically considered as basic substance (EC, 2009). The low negative impact of the constituents of lecithins on the environment due to their vegetal origin and the lack of health issues ledto an easy definition of Maximum Residue Limits (MRL) on agricultural crop production. Lecithins aregranted without MRLs. Moreover, most basic substances as lecithinsare allowed in organic farming (Marchand, 2017a). Basic substance may be used around the world for their initial uses and as biopesticides (Marchand, 2017b) after submission to local pesticide regulations.

3.3. *Discussion*

In the EU pesticide database, application of lecithin on plants is described: the method kind for lecithin is spray applicationfor all applications.

On fruit trees (Apple, Malus pumila and Peach, *Prunus persica* trees) against powdery mildews (*Podosphaera leucotricha*) and peach leaf curl (*Taphrina deformans*), lecithin is applied from the growth stage when the end of leaf bud swelling to fruits about 90% of their final size (BBCH stage 03 to 79). The product can be used 3 to 12 times with an interval of 5 days between each application. The application rate per treatment is 75 g hl^{-1} of lecithin with water from 500 to 1000 l ha^{-1}. The substance is therefore applied from 375 to 750 g ha^{-1}.

On gooseberry (*Ribes uva crispa*) against powdery mildews (*Microsphaera grossulariae*), lecithin is applied from the growth stage when the start of leafs development to the increase in intensity of cultivar-specific colour (BBCH 10 to 85). The product can be used 2 to 4 times with an interval of 5 days between each application. The application rate per treatment is 200 g hl^{-1} of lecithin with water from 500 to 1000 l ha^{-1}. The substance is therefore applied from 1000 to 2000 g ha^{-1}.

On market vegetables gardening like cucumber (*Cucumis sativus*) against powdery mildew (*Podosphaera xhantii*), lecithin is applied from the growth stage when cotyledons are spread out (BBCH stage 10 to 89). The product can be used 2 to 6 times with an interval of 5 days between each application. The application rate per treatment is 150 g hl^{-1} of lecithin with water from 1000 to 1500 l ha^{-1}. The substance is therefore applied at 1500 g ha^{-1} rate.

On lettuce (*Lactuca sativa*) against *Erysiphe cichoracearum*, lecithin is applied from the growth stage whencotyledons spread, apical vegetative point or initials of the first true visible leaves to 50% of the fruits are ripe or 50% of the seeds have their typical colour and are hard and dry (BBCH stage 10 to 89). The product can be used 2 times with an interval of 7 days between each application. The application rate per treatment is 150 g hl^{-1} of lecithin with water from 1000 to 1500 l ha^{-1}. The substance is therefore applied at 1500 g ha^{-1} amount.

On mashes (*Valerianella locusta*) against *Erysiphe polyphaga*, lecithin is applied from the growth stage when cotyledons spread, apical vegetative point or initials of the first true visible leaves to 50% of the fruits are ripe or 50% of the seeds have their typical colour and are hard and dry cotyledons spread, apical vegetative point or initials of the first true visible leaves to 50% of the fruits are ripe or 50% of the seeds have their typical colour and are hard and dry (BBCH stage 10 to 89). The product can be used in only one application. The application rate per treatment is 150 g hl^{-1} of lecithin with water from 1000 to 1500 l ha^{-1}. The substance is therefore applied 1500 g ha^{-1} rate.

On Tomato (*Lycopersicum esculentum*) against tomato blight (*Phytosphtora infestans*), lecithin is applied from the growth stage whencotyledons spread (BBCH stage 10 to 89). The product can be used 2 to 6 times with an interval of 7 days between each application. The application rate per treatment is 150 g hl^{-1} of lecithin with water from 1000 to 1500 l ha^{-1}. The substance is therefore applied 1500 g ha^{-1} rate.

On Endives (*Cichorium endiva* L.) against fungus (*Alternaria cichorii*), lecithin is applied from the growth stage when cotyledons spread, apical vegetative point or initials of the first true visible leaves to 50% of the fruits are ripe or 50% of the seeds have their typical colour and are hard and dry(BBCH stage 10 to 89). The product can be used 2 to 6 times with an interval of 7 days between each application. The application rate per treatment is 150 g hl^{-1} of lecithin with water from 1000 to 1500 l ha^{-1}. The substance is therefore applied at 1500 g ha^{-1} rate.

On ornamentals (especially roses), against powdery mildews and other fungal diseases, lecithin is applied from the growth stage when cotyledons spread (BBCH stage 10 to 89). The product can be used 3 to 12 times with an interval of 5 days between each application. The application rate per treatment is 75 g hl^{-1} of lecithin with water from 100 to 300 l ha^{-1}. The substance is therefore applied from 75 to 225 g ha^{-1}.

On grapevine (*Vitis vinifera*) against powdery mildews (*Plasmopara viticola and Erysiphe necator*), lecithin is applied from the growth stage when the first leafs spread out and are away from shoot to the ripening (BBCH stage 11 to 85). The application rate per treatment is 75 g hl^{-1} of lecithin with water from 100 to 300 l ha^{-1}. The substance is therefore applied from 75 to 225 g ha^{-1}.The minimum pre-harvest interval between the treatments is 5 days except for grapevine (30 days).

4. Conclusion

Lecithin is a foodstuff classified as food additive. In order to decrease the amount of xenobiotic pesticides released into the environment, adjuvant based on renewable sources like lecithin are requested. Lecithins can therefore be used as an antifungal biorationalpesticide(Bohinc, 2015). Lecithinsare applied as a contact product to reduce the production of fungal spores by activation of plant defences as well as direct effect on spore germination. It is an effective fungicide that can be used on fields in fruit tree, gooseberry, market vegetables, lettuces, mashes, tomatoes, endives, grapevines and ornamentals (EU pesticide database, 2017). Lecithinsare officially acknowledged as fungicide in organic farming at EU level by the common regulation (EC) No889/2008 in Annex IIas basic substance (EU, 2016).

5. Further Research

In addition to known and approved fungicidal effect,lecithin is a component of insecticidal products as lysolecithin (Taylor, 2004). Lecithin is also used in post-harvesttreatments in co-application with fludioxonil as fungicide (Schirra, 2009).Furthermore, the addition of lecithin to eugenol solutions eliminates the phytotoxic effect of eugenol at high temperature, triggering a better activation of eugenol against the pathogensforapple postharvest protection (Amiri, 2008). Furthermore, some research should be done to be able to expand uses to other fungal diseases like gray (*Botrytis cinerea*) or blue (*Penicillium* spp.) moldor as described lately (Lachhab 2015, Romanazzi, 2016).

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